Ph.D. Entrance Test Syllabus for Ph.D. in Engineering and Technology

The PET (Ph.D. Entrance test) for Ph.D. in Engineering and Technology consists of two parts:

- Part I: Research Methodology (50 marks) and
- Part II: Subject Specific (Related to the branch for 50 marks)

Total Marks for Ph.D. Entrance Test: 100 Marks

The Syllabus for Research Methodology is common to all branches of Engineering and Technology

SYLLABUS

Part I: Research Methodology (50 Marks)

1. **Introduction to Research and Research Problem**
   Meaning Of Research, Types of Research, Objectives of Research, Research and Scientific Method, Sources of Research Problem, Criteria / Characteristics Of a Good Research Problem, Errors in Selecting a Research Problem, Scope, And Objectives of Research Problem, Defining A Research Problem (Real Life Example or Case Study), Formulation of Research Hypotheses, Qualities of A Good Hypothesis.
2. **Research Design and Literature Review: Research Design**
   Concept And Importance in Research, Features of A Good Research Design, Research Designs – Experimental & Analytical Research Designs (Informal and Formal), Literature Survey- Definition of Literature and Survey, Need of Literature Survey, Objectives of Literature Survey, Sources of Literature Review. Critical Literature Review–Identifying Gap Areas from Literature Review and Strategies of Literature Survey, Errors in Research.
3. **Data Collection, Measuring, Sampling And Scaling:** Classification Of Data, Benefits And Drawbacks Of Data, Evaluation Of Data, Qualitative Methods Of Data Collection, Types Of Data Analysis, Sampling, Sample Size, Sample Design- Concept Of Probability Sampling And Non- Probability Sampling, Attitude Measurement And Scaling, Types Of Measurements, Criteria Of Good Measurements, Classification Of Scales.
4. **Data Analysis:** Testing of Hypothesis and Goodness of Fit: Definition of Null and Alternative Hypothesis, Students 'T' Distribution, Chi-Square Distribution, F-Test, Analysis of Variance Techniques, Introduction to Non-Parametric Tests. Regression Analysis – Simple Linear Regression, Multiple Linear Regression, Correlation and Regression Analysis. Introduction To

Factor Analysis, Discriminant Analysis, Cluster Analysis, Multidimensional Scaling, Multidimensional Measurement and Factor Analysis.

5. **Report, Research Proposal and Funding Agency:** Need of Effective Documentation, Types of Reports and Their Format. Essentials Of a Research Proposal. Different Funding Agencies for Research. Research Briefing, Presentation Styles, Elements of Effective Presentation, Writing of Research Paper, Presenting and Publishing Paper, Patent Procedure, Ethical Issues.

Reference Books:

- Dr. C. R. Kothari, Research Methodology: Methods and Trends, New Age International Publishers, 3rd Edition, 2014.
- Ranjit Kumar, Research Methodology: A Step by Step Guide for Beginners, SAGE Publications Ltd., 2014.
- Wayne Goddard and Stuart Melvill, Research Methodology: An Introduction, Juta and Company Ltd. 2004.

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The syllabus for each of Branch (Subject Specific) is given below:

- Ph.D. in Civil Engineering
- Ph.D. in Computer Engineering and Technology
- Ph.D. in Electronics and Communication Engineering
- Ph.D. in Mechanical Engineering
- Ph.D. in Petroleum Engineering
- Ph.D. in Polymer Engineering
- Ph.D. in Chemical Engineering

Ph.D. in Civil Engineering

Part II: Subject Specific Syllabus (50 Marks)

The subject specific Ph.D. entrance examination of civil engineering Ph.D. programme will be based on questions from 3 major areas of civil engineering, viz.

1. Structural Engineering
2. Construction Engineering & Management
3. Environmental Engineering

The questions will be based on fundamental concepts and applications in these areas. The major topics are listed below.

- Structural Engineering
  - Structural Analysis

    - RCC and Steel structure design
    - Finite Element Method
    - Structural Dynamics
    - Bio-Mechanics
- Construction Engineering & Management
    - Smart Transportation Engineering
    - Project Organization
    - Scheduling Techniques
    - Project Resource Monitoring & Control
    - Material and Safety Management
    - Quality Management
- Environmental Engineering
    - Water & Wastewater Treatment & Management
    - Air Pollution
    - Bioremediation

Reference Books:

- Analysis of Structures by Devdas Menon
- Design of RCC structures by Shaha Karve
- Design of steel Structures by Subramanyam
- Structural Dynamics by Mario Paz
- Construction Project Management by K K Chitkara
- Inventory Management by L C Jhamb
- Construction Project Management by Kumar Neeraj Jha
- Traffic Engineering and Management by Kadiyali
- Highway Engineering by Khanna Justo
- Wastewater Engineering: Treatment and Reuse by Metcalf and Eddy
- Fundamentals of Air Pollution by Daniel Vallero

Ph.D. in Computer Engineering and Technology

Part II: Subject Specific syllabus (50 Marks)

1. Engineering Mathematics

Discrete Mathematics: Propositional and first order logic. Sets, relations, functions, partial orders and lattices. Groups. Graphs: connectivity, matching, coloring. Combinatorics: counting, recurrence relations, generating functions.

Linear Algebra: Matrices, determinants, system of linear equations, eigenvalues and eigenvectors, LU decomposition.

Calculus: Limits, continuity and differentiability. Maxima and minima. Mean value theorem. Integration.

Probability: Random variables. Uniform, normal, exponential, poisson and binomial distributions. Mean, median, mode and standard deviation. Conditional probability and Bayes theorem

2. Digital Logic

Boolean algebra. Combinational and sequential circuits. Minimization. Number representations and computer arithmetic (fixed and floating point).

3. Computer Organization and Architecture

Machine instructions and addressing modes. ALU, data-path and control unit. Instruction pipelining. Memory hierarchy: cache, main memory and secondary storage; I/O interface (interrupt and DMA mode).

4. Programming and Data Structures

Programming in C. Recursion. Arrays, stacks, queues, linked lists, trees, binary search trees, binary heaps, graphs.

5. Algorithms

Searching, sorting, hashing. Asymptotic worst-case time and space complexity. Algorithm design techniques: greedy, dynamic programming and divide-and-conquer. Graph search, minimum spanning trees, shortest paths.

6. Theory of Computation

Regular expressions and finite automata. Context-free grammars and push-down automata. Regular and context-free languages, pumping lemma. Turing machines and undecidability.

7. Compiler Design

Lexical analysis, parsing, syntax-directed translation. Runtime environments. Intermediate code generation.

8. Operating System

Processes, threads, inter-process communication, concurrency, and synchronization. Deadlock. CPU scheduling. Memory management and virtual memory. File systems.

9. Databases

ER-model. Relational model: relational algebra, tuple calculus, SQL. Integrity constraints, normal forms. File organization, indexing (e.g., B and B+ trees). Transactions and concurrency control.

10. Computer Networks

Concept of layering. LAN technologies (Ethernet). Flow and error control techniques, switching. IPv4/IPv6, routers and routing algorithms (distance vector, link state). TCP/UDP and sockets, congestion control. Application layer protocols (DNS, SMTP, POP, FTP, HTTP). Basics of Wi-

Fi. Network security: authentication, basics of public key and private key cryptography, digital signatures and certificates, firewalls.

Reference Books:

- D.C. Montgomery and G.C. Runger, “Applied Statistics and Probability for Engineers”, 5th edition John Wiley and sons, New York.
- C. L. Liu, "Elements of Discrete Mathematics", McGraw-Hill
- D. C. Lay. "Linear Algebra and its Applications", 3rd Edition, Pearson, 2006.
- G. K. Binmore, " Mathematical Analysis: A Straight forward Approach", 2nd Edition, Cambridge University Press - 2010.
- George B. Thomas, D. Weir, R. Hass, "Thomas' calculus", 12th Edition, Pearson - 2013.
- William Feller, "An Introduction to Probability Theory and its Applications", Volume I & II, Wiley.
- M. Morris Mano, "Digital Design", 5th Edition, Pearson Education, 2014.
- David A Patterson, John L. Hennessy, "Computer Architecture: A Quantitative Approach", 4th Edition, Morgan Kaufmann, 2009.
- Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, "Fundamentals of Data Structures in C", 2nd Edition, University Press.
- Ellis Horowitz, Sartaj Sahni, Sanguthevar Rajasekaran, "Fundamentals of Computer Algorithms", 2nd Edition, University Press, 2008.
- John E. Hopcroft, Rajeev Motwani and Jeffrey D. Ullman, "Introduction to Automata Theory, Languages, and Computation", 3rd edition, Pearson Education.
- Alfred V. Aho, Ravi Sethi, Jeffrey D. Ullman, "Compilers: Principles, Techniques and Tools", Pearson.
- Avi Silberschatz, Peter Galvin, Greg Gagne, "Operating System Concepts", 8th Ed., Wiley Student Edition.
- Abraham Silberschatz, Henry Korth, and S. Sudarshan, "Database System Concepts", 6th Ed., McGraw- Hill.
- Andrew S. Tanenbaum, "Computer Networks", 4th Ed., Pearson.
- Stinson D., "Cryptography: Theory and Practice", 3rd Edition, Chapman and Hall/CRC, 2005.

Ph.D. in Electronics and Communication Engineering

Part II: Subject Specific syllabus (50 Marks)

Group I: Fundamentals of Electronics and Electrical Engineering:

Networks: Network theorems: superposition, Thevenin and Norton's maximum power transfer, Linear constant coefficient differential equations; time domain analysis of simple RLC circuits, Solution of network equations using Laplace transform: frequency domain analysis of RLC circuits.

Electronic Devices: Energy bands in semiconductors. p-n junction diode, Zener diode, tunnel diode, BJT, JFET, CMOS, MOSFET, LED, p-I-n and avalanche photo diode, Basics of LASERs. Device technology, Simple diode circuits, clipping, clamping, rectifier. Biasing and bias stability of transistor and FET amplifiers. Amplifiers and oscillators

Group II: Digital systems, Microprocessor & Microcontroller, Embedded System Design

Digital circuits: Boolean algebra, minimization of Boolean functions; logic gates; digital IC families (DTL, TTL, ECL, MOS, CMOS). Combinatorial circuits: arithmetic circuits, code converters, multiplexers, decoders, PROMs and PLAs, CPLD, FPGAs. Sequential circuits: latches and flip-flops, counters and shift-registers. Sample and hold circuits, ADCs, DACs. Semiconductor memories,

Embedded Systems: Basics of Embedded systems, Microprocessor and Microcontroller Architecture, Basics of Programming.

Group III: Signal and Image Processing:

Signal processing: Definitions and properties of Laplace transform, continuous-time and discrete- time Fourier series, continuous-time and discrete-time Fourier Transform, DFT and FFT, z- transform. Sampling theorem. Linear Time-Invariant (LTI) Systems: definitions and properties; causality, stability, impulse response, convolution, poles and zeros. Properties of FIR and IIR filters.

Basics of Image Processing: Calculation for memory requirement, Techniques related to Enhancement, Segmentation and Compression.

Group IV: Analog Circuits and VLSI

Analog Circuits: Small Signal Equivalent circuits of diodes, BJTs, MOSFETs and Analog CMOS. Introduction to CMOS circuits: MOS transistors, flip-flops, CMOS fabrication and layout, VLSI design flow. MOS transistor theory: Ideal I-V and C-V characteristics, nonideal I-V effects, DC transfer characteristics, Switch level RC delay models.

CMOS technologies: Layout design rules, CMOS process enhancement, Technology related CAD issues. Circuit characterization and performance estimation: Delay estimation, Logical effort and transistor sizing, Power dissipation, Interconnect design margin, Reliability, Scaling.

Group V: Communication Systems

Analog communication systems: amplitude and angle modulation and demodulation systems, spectral analysis of these operations, super heterodyne receivers; signal-to-noise ratio (SNR) calculations for amplitude modulation (AM) and frequency modulation (FM) for low noise conditions channel capacity theorem.

Digital communication systems: pulse code modulation (PCM), differential pulse code modulation (DPCM), digital modulation schemes: amplitude, phase and frequency shift keying schemes (ASK, PSK, FSK), matched filter receivers. Basics of TDMA, FDMA and CDMA and GSM. Electromagnetics: Maxwell's equations: differential and integral forms. Wave equation, Antennas: Basics of Antennas: Dipole antennas; radiation pattern; antenna gain.

Reference Books:

Group I: Fundamentals of Electronics and Electrical Engineering

- Edminister J.A., Theory and Problems of Electric Circuits, Schaum's Outline Series, McGraw Hill Book Company, 5th Edition, 1995.
- Millman's Electronic Devices and Circuits,
- Thomas L. Floyd, "Electronic devices" Conventional current version, Pearson prentice hall, 10th Edition, 2017.
- David A. Bell," Electronic devices and circuits", Oxford University higher education, 5th edition 2008.
- R. A. Gayakwad, "Op-amps and Linear Integrated circuits", PHI New delhi
- William H Hayt, J E Kemmerly and Steven M Durbin, "Engineering Circuit Analysis", Seventh Edition, McGraw Hill, 2007

Group II: Digital systems, Microprocessor & Microcontroller, Embedded System Design

- Anand Kumar - Fundamentals of Digital Circuits, PHI.
- Ramesh S. Gaonkar - Microprocessor Architecture, Programming, and Applications with the 8085.
- Muhammad Ali Mazidi and Janice Giilispie Mazidi - The 8051 Microcontroller. And Embedded Systems, Prentice Hall.
- Raj Kamal, "Embedded Systems – Architecture, Programming and Design," Mc Graw Hill Education Pvt. Ltd., 2nd Edition, 2008.
- Frank Vahid and Tony Givargis, "Embedded System Design – A Unified hardware/ Software introduction," John Wiley and sons, 3rd Edition, 2006.

Group III: Signal and Image processing:

- John G. Proakis, Dimitris G. Manolakis, — Digital Signal Processing: Principles, Algorithms and applications‖ Fourth edition, Pearson Prentice Hall.
- Ifaeachor E.C, Jervis B. W., — Digital Signal processing: Practical approach‖, Pearson Publication
- Rafael C. Gonzalez and Richard E. Woods, "Digital Image Processing", Third Edition, Pearson Education.
- S Sridhar, "Digital Image Processing", Oxford University Press.

Group IV: Analog Circuits and VLSI

- Neil H. E. Weste, David Money Harris, CMOS VLSI Design a Circuits and Systems Perspective, Pearson India, 4th Edition, 2015.
- Wyane Wolf, Modern VLSI Design (IP-Based Design), Prentice Hall, 4th Edition.
- Sung-Mo Kang, Yusuf Leblebici, Chulwoo Kim, CMOS Digital Integrated Circuits Analysis and Design, McGraw- Hill Education, 4th Indian Edition, 2016.
- Michael John Sebastian Smith, Application Specific Integrated Circuits, Pearson publications, 1 st Edition, 2002.

Group V: Communication Systems

- Simon Haykin, Digital Communication Systems, John Wiley & Sons, Fourth Edition
- B P Lathi, Zhi Ding, Modern Analog and Digital Communication System, Oxford University Press, Fourth Edition
- Taub. Schilling, Saha, Taub's Principles of Communication Systems, MGH, Fourth Edition
- Bernad Sklar, "Digital Communication Fundamentals & applications", Pearson Education. Second Edition
- William H. Hayt, Jr. and John A. Buck, Engineering Electromagnetics. McGraw Hill Higher Education, 8th Edition, 2011

- Constantine A. Balanis, Antenna Theory, Wiley-India Edition, 3rd Edition.

Ph.D. in Mechanical Engineering

Part II: Subject Specific Syllabus (50 Marks)

1. **Engineering Mechanics:** Free-body diagrams and equilibrium; trusses and frames; virtual work; kinematics and dynamics of particles and of rigid bodies in plane motion; impulse and momentum (linear and angular) and energy formulations, collisions.
2. **Mechanics of Materials:** Stress and strain, elastic constants, Poisson's ratio; Mohr's circle for plane stress and plane strain; thin cylinders; shear force and bending moment diagrams; bending and shear stresses; deflection of beams; torsion of circular shafts; Euler's theory of columns; energy methods; thermal stresses; strain gauges and rosettes; testing of materials with universal testing machine; testing of hardness and impact strength.
3. **Theory of Machines:** Displacement, velocity and acceleration analysis of plane mechanisms; dynamic analysis of linkages; cams; gears and gear trains; flywheels and governors; balancing of reciprocating and rotating masses; gyroscope.
4. **Vibrations:** Free and forced vibration of single degree of freedom systems, effect of damping; vibration isolation; resonance; critical speeds of shafts.
5. **Machine Design:** Design for static and dynamic loading; failure theories; fatigue strength and the S-N diagram; principles of the design of machine elements such as bolted, riveted and welded joints; shafts, gears, rolling and sliding contact bearings, brakes and clutches, springs.
6. **Fluid Mechanics:** Fluid properties; fluid statics, manometry, buoyancy, forces on submerged bodies, stability of floating bodies; control-volume analysis of mass, momentum and energy; fluid acceleration; differential equations of continuity and momentum; Bernoulli's equation; dimensional analysis; viscous flow of incompressible fluids, boundary layer, elementary turbulent flow, flow through pipes, head losses in pipes, bends and fittings.
7. **Heat-Transfer:** Modes of heat transfer; one dimensional heat conduction, resistance concept and electrical analogy, heat transfer through fins; unsteady heat conduction, lumped parameter system, Heisler's charts; thermal boundary layer, dimensionless parameters in free and forced convective heat transfer, heat transfer correlations for flow over flat plates and through pipes, effect of turbulence; heat exchanger performance, LMTD and NTU methods; radiative heat transfer, Stefan-Boltzmann law, Wien's displacement law, black and grey surfaces, view factors, radiation network analysis.
8. **Thermodynamics:** Thermodynamic systems and processes; properties of pure substances, behaviour of ideal and real gases; zeroth and first laws of thermodynamics, calculation of work and heat in various processes; second law of thermodynamics; thermodynamic property charts and tables, availability and irreversibility; thermodynamic relations.
9. **Applications:** *Power Engineering*: Air and gas compressors; vapour and gas power cycles, concepts of regeneration and reheat. *I.C. Engines*: Air-standard Otto, Diesel and dual cycles. *Refrigeration and air-conditioning*: Vapour and gas refrigeration and heat pump cycles; properties of moist air, psychrometric chart, basic psychrometric processes. *Turbomachinery*: Impulse and reaction principles, velocity diagrams, Pelton-wheel, Francis and Kaplan turbines.
10. **Engineering Materials**: Structure and properties of engineering materials, phase diagrams, heat treatment, stress-strain diagrams for engineering materials.

11. **Casting, Forming and Joining Processes:** Different types of castings, design of patterns, moulds and cores; solidification and cooling; riser and gating design. Plastic deformation and yield criteria; fundamentals of hot and cold working processes; load estimation for bulk (forging, rolling, extrusion, drawing) and sheet (shearing, deep drawing, bending) metal forming processes; principles of powder metallurgy. Principles of welding, brazing, soldering and adhesive bonding.
12. **Machining and Machine Tool Operations:** Mechanics of machining; basic machine tools; single and multi-point cutting tools, tool geometry and materials, tool life and wear; economics of machining; principles of non-traditional machining processes; principles of work holding, design of jigs and fixtures.
13. **Metrology and Inspection:** Limits, fits and tolerances; linear and angular measurements; comparators; gauge design; interferometry; form and finish measurement; alignment and testing methods; tolerance analysis in manufacturing and assembly.
14. **Computer Integrated Manufacturing:** Basic concepts of CAD/CAM and their integration tools.
15. **Production Planning and Control:** Forecasting models, aggregate production planning, scheduling, materials requirement planning
16. **Inventory Control:** Deterministic models; safety stock inventory control systems
17. **Operations Research:** Linear programming, simplex method, transportation, assignment, network flow models, simple queuing models, PERT and CPM

References:

- Engineering Mechanics- New Age International, S S Bhavikatti
- Engineering Mechanics, R. K. Rajput
- Strength of Materials, Dr. B.C. Punmia, Ashok Kumar Jain, Arun Kumar Jain
- The Theory of Machines, S S Ratan
- Theory of Mechanisms and Machines, A. Ghosh and A K Malik
- Mechanical Vibrations, G K Grover
- Design of Machine Elements, V. B. Bhandari
- Introduction to Fluid Mechanics & Fluid Machines, S. K. Som
- A Textbook of Fluid Mechanics, R. K. Bansal
- Heat Transfer, J. P. Holman
- Fundamentals of Engineering Heat and Mass Transfer, R C Sachdeva
- Engineering Thermodynamics, P K Nag
- Thermodynamics: An Engineering Approach, Yunus A Cengel
- Power Plant Engineering, P. K. Nag
- Refrigeration and Air Conditioning, C. P. Arora
- Internal Combustion Engines, V. Ganeshan
- Internal Combustion Engines, M. L. Mathur, R. P. Sharma
- Materials Science and Engineering An Introduction - Callister 9e.
- Production Technology: Manufacturing Processes, Technology and Automation, R K Jain
- Production Technology: Manufacturing Processes, Technology and Automation, R K Jain
- Metrology and Quality Control, Mahajan
- Automation, Production Systems, Computer Integrated manufacturing, Groover
- Industrial Engineering and Management, O P Khanna

- Industrial Engineering and Management, O P Khanna
- Operations Research, Prem Kumar Gupta and D. S. Hira

Ph.D. in Petroleum Engineering

Part II: Subject Specific syllabus (50 Marks)

1. Engineering Mathematics: Matrix algebra, systems of linear equations, Eigen values and eigenvectors. Calculus: functions of single variable, limit, continuity and differentiability, partial derivatives, total derivative, maxima and minima, gradient. First order equations (linear and nonlinear), higher order linear differential Equations with constant coefficients, Laplace transforms. Numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule. Numerical methods for root determination and optimization.

2. Petroleum Exploration: Petroleum System: Source, reservoir, migration, trap and seal. Lead, Play and Prospect. Gravity and magnetic methods. Electrical resistivity methods- VES Wenner and Schlumberger array. Seismic methods, Acquisition, Processing and Interpretation, Attribute Analysis. Formation evaluation using standard wireline logs.

3. Reservoir Engineering

Petro physical properties. Darcy's law. Rock fluid interactions. Fluid and rock properties. Phase behavior of hydrocarbon system. Reservoir drive mechanism. Reserve determination (volumetric, material balance, decline curve, P/Z method), PVT Analysis, Material Balance, Flow in porous media. Fluid Coning. Reservoir Pressure measurements and maintenance. Well test analysis. Static and dynamic modeling, Unconventional Hydrocarbon Resources, Formation Evaluation and Well Testing methods.

4. Drilling Engineering: Well planning. Drilling Rigs. Mud Hydraulics. Casing Practices. Drill String. Bits and their classification. Drilling problems and remedies. Drilling fluids. Safety, Health and Environment, HAZOP and HAZID, Offshore Drilling and Waste Management. Cementing Techniques. Directional Survey. Dog-log severity. Advance drilling methods – ERD, horizontal drilling, multilateral drilling.

5. Production Engineering: Well Equipment. Well head assembly. Packers. Tubing Strings. Well completion – techniques and design. Well Activation. Swabbing. Well Perforation. Well Stimulation. Artificial Lift Techniques. Production Optimization Techniques, Nodal Analysis. Storage and Transportation, Storage Tanks, Pumps and Compressors. Separation of Oil and Gas. GGS. Oil and Gas Metering and Processing, Offshore Production Systems.

Reference Books

- Steven C. Chapra, Raymond P. Canale, Numerical Methods for Engineers, 4/e, Tata McGraw Hill Editions.
- Dr. B. S. Garewal, Numerical Methods in Engineering and Science, Khanna Publishers.
- Rider, M. H., "The Geological Interpretation of Well Logs" John Wiley Publishing Company
- Asquith George & Krygowski Daniel, 2004, Basic Well Log Analysis. USA. AAPG.
- Whitaker A., 1985 "Formation Evaluation" IHRDC.
- John R. Fanchi and Richard L. Christiansen, "Introduction to Petroleum Engineering," Published by John Wiley & Sons, Inc., Hoboken, New Jersey. June 2016.
- Dake L. P., 1994, The Practice of Reservoir Engineering, Developments in Petroleum

- Science, 36, Elsevier, 568 pp.

- H. Rabia, 1985, "Oil Well Drilling Engineering, Principles and Practice," Graham Trotman Limited UK and Graham Trotman Inc., USA.
- Rao Ramchandra M.B., 1987, "Outline of Geophysical Prospecting", EBD Publishing.

b. Philip Kearey, Michael Brooks Ian Hill, Blackwell Science, An Introduction to Geophysical Exploration

- H. Rabia, 1985, "Oil Well Drilling Engineering, Principles and Practice," Graham Trotman Limited UK and Graham Trotman Inc., USA.
- Adam T. Bourgoyne Jr., Keith K., Millheim, Martin E. Chenevert M E and F. S. Young Jr. 1991, "Applied Drilling Engineering," SPE Text Book Series, USA.
- Robert F. Mitchell, Stifan Z. Miska, Society of Petroleum Engineers, "Fundamentals of Drilling Engineering", SPE Text Book Series Volume 12, USA
- T. E. W. Nind, 1981,"Principles of Oil Well Production", McGrew Hill Technology and Engineering.
- BoyunGuo, William C. Lyons and Ali Ghalambor, "Petroleum Production Engineering A Computer-Assisted Approach". February 2007, Elsevier Science & Technology Books.
- Economides M. J.; Hill A. D.; Economides C. E.; Petroleum Production Systems; Prentice Hall, Petroleum Engineering Series.
- Danish Ali, 1998, PVT and Phase Behavior of Petroleum Reservoir Fluids. Elsevier, 400 pp.
- H. Dale Beggs, "G a s Production Operations"., OGCI Publications Oil and Gas Consultants international Inc. Tulsa
- Craft B. C. and Hawkins M F, 1991, Applied Petroleum Reservoir Engineering, 2nd edition, Prentice Hall, 431 pp
- Dake L. P., 1994, The Practice of Reservoir Engineering, Developments in PetroleumScience, 36, Elsevier, 568 pp.
- Dandekar A. Y., 2011, Petroleum Reservoir Rock and Fluid Properties, Taylor and Francis.
- Tiab D, and Donaldson E.C., 2012, Petrophysics; 3rd edition, Gulf Publishing Co, 956 pp.
- Lee, W.J., Rollins, J.B., and Spivey, J.P.: Pressure Transient Testing, SPE (2003)
- Earlougher, R.C., Jr.: Advances in Well Test Analysis, Monograph Vol. 5, SPE (1977)
- Horne, R.N.: Modern Well Test Analysis: A Computer-Aided Approach (1995).
- Lee, W.J. and Wattenbarger, R.A.: Gas Reservoir Engineering, SPE (1996).
- Dake, L. P.: Fundamentals of Reservoir Engineering, Elsevier (1978).
- Dake, L. P.: The Practice of Reservoir Engineering, Elsevier (2001).
- Bourdet, D.: Well Test Analysis: The Use of Advanced Interpretation Models, Elsevier (2002).
- Raghavan, R.: Well Test Analysis, Prentice Hall (1993).

Ph.D. in Polymer Engineering

Part II: Subject Specific syllabus (50 Marks)

1. Engineering Mathematics:
Linear algebra: matrix algebra, systems of linear equations, Eigen values and eigenvectors. Calculus: functions of single variable, limit, continuity and differentiability, partial derivatives, total derivative, maxima and minima, gradient.
Differential equations: first order equations (linear and nonlinear), higher order linear differential Equations with constant coefficients, Laplace transforms
Numerical methods: numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule.

2. Polymer Materials: Types of Materials, Properties and their Applications: Thermoplastics, thermosetting, elastomers and rubbers, blends and alloys, natural polymers, engineering polymers, specialty materials, liquid crystalline polymers; additives.

3. Polymer Synthesis: Addition, condensation polymerization; bulk, suspension, solution and emulsion polymerization techniques, co-ordination catalysts, molecular weight, molecular weight distribution,

4. Polymer Rheology and Processing: Viscoelasticity, rheometry, Injection molding, extrusion, compression and transfer molding, rotational molding, calendaring, thermoforming, filament winding, pultrusion

5. Polymer Testing and Characterization: Mechanical, thermal, electrical, weathering and flammability properties, microscopy, chromatography, diffraction techniques,

6. Mold and Die Design: Feed, cooling and ejection techniques, hot runner molds, split and side core, flat film and sheet dies

References:

- Brydson J., Plastics Materials, 7th edition, Elsevier, 2005
- Odian G., Principles of Polymerization, 4 th edition, Wiley India Pvt. Ltd., 2004
- Fried J.R., Polymer Science and Technology, 2 nd edition, PHI Publications Pvt. Ltd., 2004
- Macasko C. W., "Rheology: Principles, Measurements and Applications", Wiley VCH, 1994
- Crawford R.J., Plastics Engineering, 3rdedition, Butterworth–Heinemann, 2006
- Shah V., "Handbook of Plastics Testing Technology", 2nd edition, John Wiley and Sons Inc., New York, 2008
- Brown R., "Handbook of Polymer Testing: Physical Methods", CRC Press, 1999
- Pye R.C.W., "Injection Mold Design", 4th ed., East-west Press Pvt. Ltd

Ph.D. in Chemical Engineering

Part II: Subject Specific syllabus (50 Marks)

1. **Engineering Mathematics:**
   - **Linear Algebra:** matrix algebra, systems of linear equations, Eigen values and eigenvectors.
   - Calculus: functions of single variable, limit, continuity and differentiability, partial derivatives, total derivative, maxima and minima, gradient.
   - **Differential Equations:** first order equations (linear and nonlinear), higher order linear differential Equations with constant coefficients, Laplace transforms
   - **Numerical methods:** numerical solutions of linear and non-linear algebraic equations. Integration by trapezoidal and Simpson's rule.
2. **Process Calculations and Thermodynamics:** Steady and unsteady state mass and energy balances including multiphase, multi-component, reacting and non-reacting systems. Use of tie components; recycle, bypass and purge calculations; Gibb's phase rule and degree of freedom analysis. First and Second laws of thermodynamics. Applications of first law to close and open systems. Second law and Entropy. Thermodynamic properties of pure substances: Equation of State and residual properties, properties of mixtures: partial molar properties, fugacity, excess properties and activity coefficients; phase equilibria: predicting VLE of systems; chemical reaction equilibrium.
3. **Fluid Mechanics:** Fluid statics, Newtonian and non-Newtonian fluids, shell-balances including differential form of Bernoulli equation and energy balance, Macroscopic friction factors, flow through pipeline systems, flow meters, pumps and compressors, elementary boundary layer theory, flow past immersed bodies including packed and fluidized beds.
4. **Heat Transfer:** Steady and unsteady heat conduction, convection and radiation, thermal boundary layer and heat transfer coefficients, boiling, condensation and evaporation; types of heat exchangers and evaporators and their process calculations. Design of double pipe, shell and tube heat exchangers, single and multiple effect evaporators.
5. **Mass Transfer:** Fick's laws, molecular diffusion in fluids, mass transfer coefficients, film, penetration and surface renewal theories; momentum, heat and mass transfer analogies; stage-wise and continuous contacting and stage efficiencies; HTU & NTU concepts; design and operation of equipment for distillation, absorption, leaching, liquid-liquid extraction, drying, humidification, dehumidification and adsorption.
6. **Chemical Reaction Engineering:** Theories of reaction rates; kinetics of homogeneous reactions, interpretation of kinetic data, single and multiple reactions in ideal reactors, non- ideal reactors; residence time distribution, single parameter model; non-isothermal reactors; kinetics of heterogeneous catalytic reactions; diffusion effects in catalysis.
7. **Instrumentation and Process Control:** Measurement of process variables; sensors, transducers and their dynamics, process modeling and linearization, transfer functions and dynamic responses of various systems, systems with inverse response, process reaction curve, controller modes (P, PI, and PID); control valves; analysis of closed loop systems including stability, frequency response, controller tuning, cascade and feed forward control.
8. **Chemical Technology: Inorganic** chemical industries (sulfuric acid, phosphoric acid, Chlor-alkali industry), fertilizers (Ammonia, Urea, SSP and TSP); natural products industries (Pulp and Paper, Sugar, Oil, and Fats); petroleum refining and petrochemicals.

polymerization industries (polyethylene, polypropylene, PVC, and polyester synthetic fibers).

9. **Plant Design and Economics:** Principles of process economics and cost estimation including depreciation and total annualized cost, cost indices, rate of return, payback period, discounted cash flow, optimization in process design and sizing of chemical engineering equipments such as compressors, heat exchangers, multistage contactors.

Reference Books:

- M.L. Shuler and F. Kargi, "Bioprocess engineering", 2nd Edition, Prentice Hall of India, New Delhi. 2002.
- J. E. Bailey and D.F. Ollis, "Biochemical Engineering Fundamentals", 2nd Ed., McGraw- Hill Publishing Co. New York. 1986.
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